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## Variable effect of comorbidity on the association of chronic cardiac failure with disability in community-dwelling older persons

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### Abstract

The effect of cardiac failure (CF) and comorbidity on disability in older persons was studied in a cross-sectional survey. The whole population aged 65 + years ( $n = 652$ ; 628 eligible) living in a small town near Florence (Italy) was enrolled. Finally, 459 individuals (73.0% of eligible) underwent a multidimensional evaluation. CF was defined as a NYHA II–IV class in the presence of an obviously abnormal ECG. Disability was assessed by the 14-item WHO scale. Comorbid conditions that had a prevalence  $> 5\%$  and might be considered pathophysiologically unrelated to CF were also identified. The univariate association of CF with disability was analyzed. Multivariate associations were estimated as well, by taking simultaneously into account the effect of comorbid conditions that had an independent effect on disability and were considered as either confounders or effect modifiers of that association. Prevalence of CF [6.1% in the whole study population] was higher with advancing age ( $\geq 75$  years: 8.3 versus 65–74 years: 4.5%, odds ratio, OR: 1.93, 95%

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confidence interval, CI: 1.02–4.18), in the presence of hypertension (OR: 2.87, 95% CI: 1.32–6.23), and among individuals who were living alone (OR: 2.44, 95% CI: 1.10–5.56). CF was associated with a higher prevalence of disability (38.5 versus 19.5%; OR 2.67, 95% CI: 1.21–5.92). Comorbidity modified the association of CF with disability following two patterns: while the independent effect of CF on the prevalence of disability was similar in the absence or in the presence of chronic obstructive pulmonary disease, hearing impairment, gastrointestinal tract disease, or osteoarthritis, such effect was much larger in the presence than in the absence of visual impairment, previous stroke, or urinary incontinence. The composite pathophysiological pathways of such different interactions are still to be elucidated. Copyright © 1996 Elsevier Science Ireland Ltd

**Keywords:** Disability; Cardiac failure; Comorbidity; Chronic diseases

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## 1. Introduction

Several epidemiological surveys based either on mortality or on clinical data and carried out at the population level (Gillum, 1993; Ho et al., 1993) or in hospital settings (Ghali et al., 1990; McMurray et al., 1993; Centers for Disease Control and Prevention, 1994) have constantly shown an exponential growth of the prevalence and the incidence of chronic cardiac failure (CF) with age. Moreover, since in the future decades mortality will be postponed more markedly than incidence, the morbidity rate for CF is expected to decrease among the young and middle-aged and to increase further among the elderly (Bonneux et al., 1994). The different sensitivity and specificity of selected diagnostic criteria may have been, at least in part, responsible for the slightly different prevalences of CF that have been reported by epidemiological studies carried out in different countries and settings. The prevalence, for example, was lower in the Framingham study (Ho et al., 1993), that adopted a complex combination of major and minor criteria to diagnose CF, than in a longitudinal study of the aged population living in Gothenburg where, following much less restrictive criteria, a prevalence larger than 10% was found among men older than 65 years (Eriksson et al., 1989). However, independently of different absolute values, all studies with few exceptions (Bild et al., 1993) reported the same age-related positive trend, confirming therefore that advanced age is, beyond hypertension, diabetes, elevated blood cholesterol and smoking habits, the most powerful risk factor for CF.

The effect of CF as a risk factor for disability (Bild et al., 1993), particularly when it presents in association with other chronic diseases, has been analyzed much less extensively. According to the Framingham study, CF produced significant functional limitations in several tasks such as stair climbing, making heavy home chores, housekeeping and carrying bundles (Guccione et al., 1994). However, since comorbidity is also very much common in advanced age and has an obviously more negative impact on physical functioning than a single chronic condition (Ferrucci et

al., 1991; Guccione et al., 1994), it would be of interest to measure the effect of CF, alone or in combination with different comorbid conditions, on the risk of disability. The present epidemiological survey of a non-institutionalized elderly population was designed to assess whether the effect of CF on disability may vary in relation to its association with other chronic conditions.

## 2. Methods

### 2.1. Study population and data collection

The study population consisted of the 652 individuals aged 65 years and over (18% of the general population), living in a small town (Dicomano, 3622 inhabitants) near Florence (Italy). Of these, 169 refused to participate in the study or had moved away and could not be traced, and 24 had already died or were in institutions: 459 subjects (73.0% of the eligible population of 628 subjects) were therefore finally available for data collection and analysis. Physical health and functional status, mental and socio-economic conditions were assessed by a formal clinical examination and by a structured questionnaire derived from that originally used in the Eleven Countries Study (Heikkinen et al., 1983). Using a checklist of conditions most prevalent in the elderly, chronic diseases were identified by medical history and by physical examination that was carried out by an expert geriatrician following pre-established criteria. Arterial hypertension was defined by three consecutive (10 min apart) measurements by the standard cuff method in the sitting position, all showing a systolic pressure  $\geq 160$  and/or a diastolic pressure  $\geq 95$  mmHg. Subjects with a history of hypertension and normal pressure values while receiving anti-hypertensive medications, were considered hypertensive as well. A standard 12-lead ECG was recorded during the clinical visit and it was coded as abnormal when indicated coronary heart disease or left ventricular hypertrophy/strain (Minnesota codes 1.1 or 1.2, 4.1–4.4, or 5.1–5.3) (Blackburn et al., 1960) or showed left bundle branch block, complete atrio-ventricular block, or chronic atrial fibrillation. Functional conditions were determined using the 14-item WHO scale, which takes into account both the basic and the instrumental activities of daily living (Ferrucci et al., 1991). Disability was identified by breaking the continuous score of the 14-item scale into three separate levels of physical functioning (namely: independence versus moderate or severe disability) that require different degrees of care in daily life, according to a previously validated method (Ferrucci et al., 1991). CF was defined as the association of a New York Heart Association (NYHA) II–IV class (The Criteria Committee of the New York Heart Association, 1994) with an unequivocally abnormal 12-lead ECG as described above.

### 2.2. Statistical analysis

Data were analyzed using the SAS statistical package. The association between categorical variables was analyzed by the  $\chi^2$  test, computing the odds ratio (OR)

and the 95% confidence interval (CI). Stratification techniques (Mantel-Haenszel OR: M-H OR) and multiple logistic regression analysis were used to analyze the effect of potential confounders. Parameters of the logistic function were determined using the iterative maximum likelihood technique described by Walker and Duncan (Walker and Duncan, 1967). Estimates of risk were derived from the coefficients and 95% CIs were calculated as well. Data are given as mean  $\pm$  standard deviation. A  $P$  value  $< 0.05$  was considered statistically significant.

### 3. Results

#### 3.1. Prevalence of cardiac failure and risk factors

The prevalence of CF was 6.1% in the whole study population, increasing significantly with advancing age ( $\geq 75$  years: 8.3 versus 65–74 years: 4.5%; OR 1.93, 95% CI 1.02–4.18) and in the presence of arterial hypertension (hypertensives: 11.5 versus normotensives: 4.3%; OR 2.87, 95% CI 1.32–6.23). No one of the other classical risk factors (that is diabetes mellitus, hyperlipidemia, smoking habits) was significantly associated with the prevalence of CF. A considerably higher prevalence among women than men did not attain statistical significance (women: 7.4 versus men: 4.7%; OR 1.62, 95% CI 0.93–3.59). Marital status was the only socio-economic variable associated with the risk of CF, whose prevalence was significantly lower (OR 0.41, 95% CI 0.18–0.91) among those who were married or were living with a partner (3.9%) as compared with those who were widowed/divorced/unmarried and were living alone (9.0%).

#### 3.2. Cardiac failure, general state of health and disability

CF was significantly associated with several indirect measures of physical health. In particular, subjects with CF had spent more frequently  $\geq 15$  days in bed (CF: 23.1 versus no CF: 7.5%; OR 3.40, 95% CI 1.29–9.99) or in hospital (CF: 23.1 versus no CF: 5.6%; OR 4.63, 95% CI 1.71–12.48) in the last six months, they rated their health status as poor in a larger proportion (CF: 64.0 versus no CF: 42.1%, OR 2.46, 95% CI 1.11–5.46), and were experiencing more frequently a sensation of fatigue (CF: 76.9 versus no CF: 39.5%; OR 5.63, 95% CI 2.24–14.17). These findings seemed to be independent effects of CF, since they were not the consequences of a greater number of comorbid conditions (CF:  $1.82 \pm 1.42$  versus no CF:  $1.82 \pm 1.23$  chronic diseases/person,  $P = 0.992$ ) or of more frequent or severe depressive symptoms evaluated by the Geriatric Depression Scale (Yesavage et al., 1983) (CF: 34.8 versus no CF: 26.7% of subjects with GDS score  $\geq 14$ ; OR 1.53, 95% CI 0.68–3.41; GDS score CF:  $20.04 \pm 6.85$  versus no CF:  $20.61 \pm 6.34$ ,  $P = 0.690$ ).

In spite of the similar number of comorbid conditions, CF was associated with an evident loss of functional independence. Indeed, the prevalence of disability (moderate or severe disability versus independence) (Ferrucci et al., 1991) was almost

double in the presence of CF (CF: 38.5 versus no CF: 19.5%; OR 2.67, 95% CI 1.21–5.92).

The interaction of CF with chronic comorbidity in modifying the probability of functional impairment was assessed by comparing the effect of CF on disability in the presence, with that in the absence of several comorbid conditions. In particular, the effects of these associations were tested for seven chronic conditions that had a prevalence of more than 5% in the whole study population, were significantly associated with disability and, as stated above, could be considered pathophysiologically unrelated to CF. By this method, two distinct patterns could be identified for the effect of comorbidity. According to the first pattern, CF was associated with an increased risk of disability that was quantitatively independent of the association with certain comorbid conditions. In fact, the risk of disability that could be attributed to CF increased by about 2–3 times both in the absence and in the presence of chronic obstructive pulmonary disease, hearing impairment, gastrointestinal tract disease, or osteoarthritis (Fig. 1). Following the second pattern instead, the effect of CF on the risk of disability was much larger in the presence than in the absence of visual impairment, previous stroke, or urinary incontinence (Fig. 2), conditions that were therefore synergistic with CF in causing functional impairment.

#### 4. Discussion

This survey of a non-institutionalized, aged population confirmed the high prevalence of CF among older persons. In particular, the prevalence of 6.1% that has been found in the present study compares well with data from previous, large epidemiological surveys carried out at the general population level, in spite of the different criteria adopted to define CF (Eriksson et al., 1989; Gillum, 1993; Ho et al., 1993). Interestingly, an identical prevalence of 6.0% has already been reported among community-dwelling individuals aged 65+ years in the USA (Luchi et al., 1991). Furthermore, it was confirmed that the prevalence of CF increases stepwise with age even through a single decade, and that at older ages it tends to be higher among women than men (Ho et al., 1993). These data further stress the need for clinical studies specifically designed to test the efficacy of drugs to treat CF in the elderly (Aronow and Kronzon, 1993; Rogers et al., 1994) and, perhaps most importantly, for large trials aimed at assessing the effectiveness of preventive strategies for CF, together with other major cardiovascular events in advanced age (SHEP Cooperative Research Group, 1991).

Of the classical cardiovascular risk factors that have been generally confirmed to maintain their significance at older ages (Ho et al., 1993), only hypertension was significantly associated with an increased prevalence of CF in the present study. The lack of any association with other risk factors, such as smoking habits, diabetes and hyperlipidemia, is probably the consequence of selective survival — a typical limitation of cross-sectional studies — and/or of the limited numerosity of the population surveyed.

A recent follow-up study demonstrated that one-year mortality of elderly patients after myocardial infarction is influenced by left ventricular ejection fraction or NYHA functional class (The Criteria Committee of the New York Heart Association, 1994), and also by an index of the density of social network (Berkman et al., 1992). Thus, it is not surprising that living with a partner resulted to be protective against CF in the present survey. Though this finding might have resulted from some confounder (e.g. those living alone might have been most often older females),

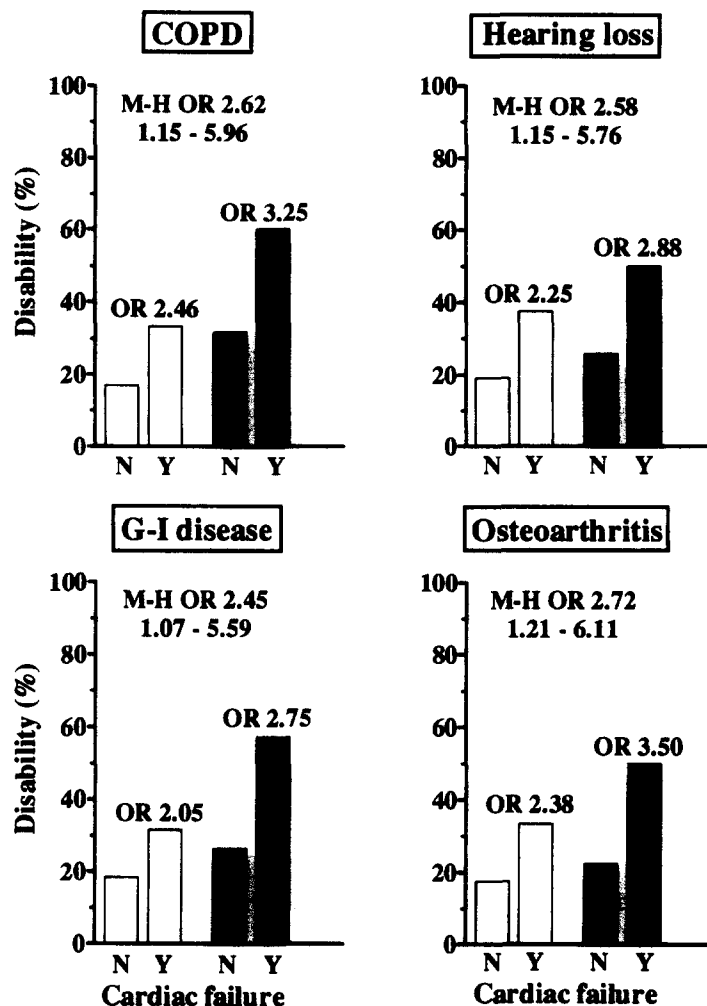


Fig. 1. Prevalence of disability (14-item WHO scale) by absence/presence (N/Y) of cardiac failure (for definition, see text) and of chronic comorbid conditions (absent: open bars; present: closed bars). The odds ratio values (OR) refer to the increased prevalence of disability due to cardiac failure. COPD = chronic obstructive pulmonary disease; G-I disease = gastro-intestinal tract disease; M-H OR = Mantel-Haenszel odds ratio.

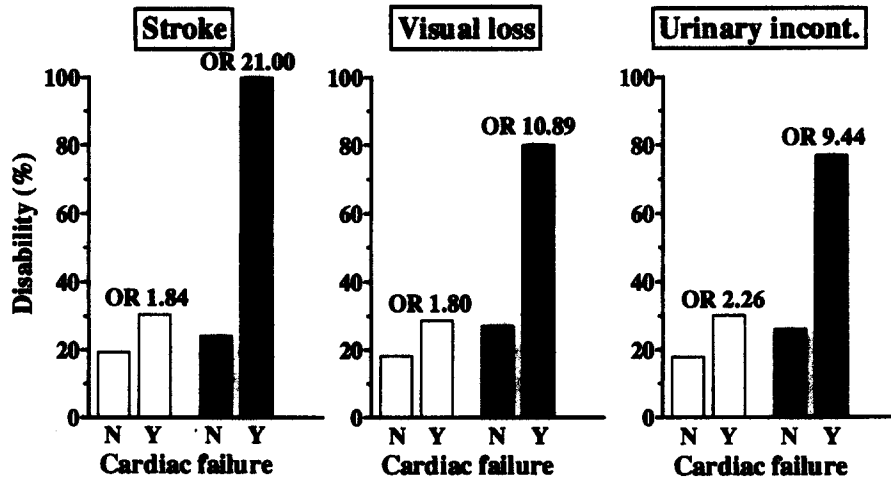


Fig. 2. Prevalence of disability by absence/presence of cardiac failure and of chronic comorbid conditions. Urinary incontinence = urinary incontinence. Other abbreviations, symbols and definitions as in Fig. 1.

we believe that it confirms that evaluation of health status at older ages must encompass conventional (either generic or disease-specific) biological indicators, and also a comprehensive assessment of parameters pertinent to different domains.

CF has been demonstrated to limit independence in several tasks (Guccione et al., 1994), to have a significantly negative impact on determinants of the quality of life (Guyatt, 1993), to bear an increased risk of disability in older individuals living in the community (Pinsky et al., 1990), and to increase the risk for loss of employment in younger (< 65 year-old) patients with chronic coronary artery disease (Mark et al., 1992). Conversely, it was demonstrated in CF patients that the evaluation of physical function by the 6-min walk test is a predictor of mortality and of the rate of hospital admissions stronger than left ventricular ejection fraction (Bittner et al., 1993). Our data are substantially consistent with these reports. Indeed, the univariate analyses in the present study demonstrated that CF is associated with an increased need for health services and with a higher prevalence of some of the usual indicators of a bad health-related quality of life (Guyatt, 1993), such as a poor self-rated health and the perception of fatigue.

In the Framingham disability study (Pinsky et al., 1990), when several clinical manifestations of coronary heart disease were put together and examined by logistic regression functions, only complicated or uncomplicated angina pectoris maintained their statistical significance as independent causes of disability at whatsoever age, whilst CF was a significantly disabling condition only among younger (55–69 years) women. On the other hand, many subjects reporting disability do ascribe their functional limitation to cardiovascular symptoms typi-



cal of CF, such as dyspnoea (Ettinger et al., 1994). Furthermore, CF in the Framingham study had the lowest prevalence ever observed in the community (largely < 3%) (Pinsky et al., 1990). Thus, one might argue that several subjects reporting chest discomfort and light dyspnoea under effort — symptoms that may be an atypical presentation of myocardial ischemia quite commonly encountered in the elderly (Kannel and Abbot, 1984) — have been classified as angina patients in the Framingham study (Pinsky et al., 1990) and as CF patients in the present study.

Again, in the Framingham study (Pinsky et al., 1990), the association between angina pectoris or CF and the prevalence of disability did not change when several chronic conditions were simultaneously introduced as additional covariates into the logistic regression models. This result was confirmed by our data which demonstrated, at least for certain covariates, that the independent association between CF and the risk of disability was substantially unchanged when a covariate was introduced into the model. However, no attempt had been made in the past to determine whether this behaviour is maintained constant for a wide spectrum of possible covariates. Having analyzed various co-associations separately, we could distinguish between interactions with largely different effects.

The reasons for the greater disabling impact of CF with certain associations as compared with others are unclear and they should rely on complex pathophysiological mechanisms, still to be investigated. Nevertheless some hypotheses, that are potential objectives for future research, can be made. Functional independence after a stroke can be maintained, or at least preserved, thanks to alternative patterns of movement. These coping strategies may impose a greater burden to the cardiocirculatory and respiratory systems, possibly by demanding more oxygen for the working muscles to carry out any physical task. In this context the occurrence of CF, that reduces cardiocirculatory reserve, would substantially limit patient's ability to cope, thereby precipitating him/her toward a state of severe disability (Fried et al., 1991). Alternatively, CF and other chronic conditions might share some risk factors (e.g. diabetes mellitus inducing severe CF secondary to coronary heart disease and retinopathy with visual impairment, that could act as the pathophysiological basis for their synergistic effect on disability. This hypothesis could not be further investigated, since information on the severity of individual diseases were not available in this study.

In summary, the results of the present study on one hand confirmed at a population level the high prevalence of CF among elderly individuals and the burden of disability that is independently associated with it. On the other hand, perhaps more interestingly, they underlined the complexity of the relationship between morbidity, co-morbidity and resulting disability. The variability of this relationship, whose origin is still to be clarified, suggests that preventive strategies against disability should be guided not only by data on the prevalence of diseases, but also by the knowledge of the different strength(s) by which different comorbid associations may affect the pathway which entails loss of independence at older age.

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